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REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 28, 1923.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1923.

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. HENRY C. WALLACE,
Secretary of Agriculture.

DECIDUOUS FRUIT INSECT INVESTIGATIONS.

Investigations of deciduous fruit insects have been carried out under the direction of Dr. A. L. Quaintance, as formerly.

THE JAPANESE BEETLE.—Work against the Japanese beetle in co-operation with the Federal Horticultural Board and the New Jersey and Pennsylvania State Departments of Agriculture has been vigorously prosecuted. It is subdivided into the following sections: Administration, quarantine enforcement, biologic investigations, beetle insecticide investigations, grub insecticide investigations, and field work. The regulations established in Federal Quarantine 48, as well as the restrictions of the quarantine laws of Pennsylvania and New Jersey, have been enforced during the year. Something over 483,000 baskets of corn were inspected during the summer and fall of 1922, and many thousands of beetles were removed from the corn before shipping certificates were given. A large amount of inspection of nursery, ornamental, and greenhouse products has been done and certificates issued when the owner was entitled to them. Scouting to determine limits of infestation has been carried out as heretofore and reveals a constant natural spread of the beetle which can not be prevented. Thus at the beginning of the season of 1922 the infested area covered some 270 square miles, while at the close of that season it had spread to over 770 square miles, representing a spread of about 200 per cent.

Much additional information has been accumulated on the biology of the insect and also on its behavior under varying environmental conditions. The relationship existing between common farm practices in the community and grub infestation has also been carefully studied, and it appears that present farm practices are favorable to the insect. Certain modifications appear desirable from the standpoint of control of the beetle, such as extremely late fall plowing and late spring plowing, which tend to reduce the number of grubs.

One of the principal activities under this heading has to do with the importation of foreign parasites. Several shipments of beneficial

parasites have been received during the year from Japan, Korea, and Hawaii. Colonies of a few species have been released in the field and there is good reason to believe that some, at least, may be able to establish themselves. Abroad the work is being conducted from Yokohama, with substations at Koiwai in northern Hondo, Sapporo in Hokkaido, and Suigen, Korea. A species of *Tiphia* has been collected and reared at Koiwai and a shipment of 2,100 cocoons was dispatched to Riverton, N. J., in October, where they arrived in good condition. Around Yokohama a tachinid, *Ochroemeigenia ormioides*, has been found attacking the adult Japanese beetle, and a sizable shipment of this species to New Jersey was made during June. From the region of Sapporo a tachinid, *Centeter cinerea*, parasitic on the adult beetle, has been collected in numbers and carefully studied. A large shipment of this species was sent to New Jersey in October, 1922, and beetles bearing eggs were found there the present summer, indicating that the species has gained a foothold. Another parasite, a dextiid fly, was collected and material bred in some quantity at Koiwai and a shipment made to Riverton in October. It is too soon to say whether this species has become established. A dextiid from Korea is also under investigation and after further study may prove to be a valuable parasite of the beetle. In addition to the above a *Tiphia* from Korea gives promise of considerable value, as it occurs in the spring of the year and thus supplements a fall species from northern Japan.

Enlargement of the foreign parasite work has been effected. Two more experienced agents have been employed and are now in the Orient, bringing the number of agents to four. The bureau is fortunate to have the active cooperation of Japanese entomologists in this work, which has added greatly to its effectiveness. A search for parasites will be undertaken in China and India, where species of the genus *Popillia* are numerous. In addition to the material coming from Japan, a large shipment of the wasp *Scolia manilae* was made from Hawaii into New Jersey, but it is doubtful whether this insect will be able to withstand the rigors of this latitude and climate. In this importation work the cooperation of quarantine officials at San Francisco and Seattle, and also of officers of steamship companies and express companies, has been of the greatest value.

In addition to the beetle parasite work in Japan, attention has been given by the agents there to obtaining, if possible, parasites of other insects, such as the oriental fruit moth, citrus white fly, camphor scale, red scale, *Citricola* scale, etc., and some introductions have been made. The employees at Riverton are carefully investigating the possibility of utilizing native parasites against the Japanese beetle, and studies thus far indicate that but a very small per cent of the insects are destroyed by native forms.

Attention is also being directed to the utilization of possible fungous and bacterial diseases of the Japanese beetle, particularly those attacking the larval stage. Several bacterial diseases have been isolated from dead or dying Japanese beetle grubs and cultures made. From these cultures, tests are in progress to determine to what extent they are pathogenic, by inoculating healthy grubs in the laboratory and the soil in the field. A species of *Isaria* from France is being cultivated and experiments made to determine its possible value when disseminated in infested pastures and elsewhere.

An extensive study of the feeding habits of the Japanese beetle has been carried on for several seasons and data brought together in a paper on Feeding Habits of the Japanese Beetle which Influence its Control, published as Department Bulletin 1154.

Extensive experiments have been made in replacing the soil ball of coniferous nursery stock with an artificially made ball free from grub infestation to permit the movement of such stock by nurserymen from the infested area. A fair proportion of plants thus handled have come through the second season after such treatment quite satisfactorily, and it is believed that this method gives promise for the use of nurserymen interested in the movement of such stock.

Much attention has been given to the investigation of insecticides for the destruction of the beetles and to kill the grubs in the soil. A fair killing of the beetles was secured from the use of arsenate of lead at the rate of 4 pounds to 50 gallons of water with 2 pounds of flour or casein spreader. One or two applications in most cases were sufficient when applied thoroughly to protect the foliage during the beetle season. Further experiments have pointed out certain improvements in arsenical sprays, which, however, must be subjected to further investigation before definite conclusions are warranted. Many materials have been tried in the hope of finding a substitute for arsenicals for use against the beetle without, however, very much success thus far. Large-scale spraying work has been done in orchards during the beetle season to ascertain the degree of protection from attack which follows different spraying practices. The results show that orchardists can protect their trees and fruit from the beetle by thorough and timely applications of arsenate of lead. Substantial progress has been made in perfecting methods of treatment of infested outdoor-grown nursery stock for the destruction of grubs which may be in the soil around the roots. While no one treatment of universal application has been worked out, several have been developed which are of value under varying conditions.

Methods for the treatment of soil in which infested or noninfested nursery stock may be heeled in have been investigated. Arsenate of lead worked thoroughly into the soil has given rather satisfactory results. Further work, however, must be done before this method is recommended, especially to determine the tolerance of different plants to soil treated with arsenate of lead. The destruction of grubs in infested grass lands, such as golf greens and fairways, can be accomplished, it has been found, by the use of carbon disulphid emulsion. In this way the grub population in sod land can be reduced at a reasonable cost from 60 to 75 per cent.

GRAPE INSECTS.—Investigations of grape insects in cooperation with the Ohio Agricultural Experiment Station, with headquarters at Sandusky, Ohio, have been continued, special attention being given to the three-banded grape leafhopper, *Erythroneura tricincta*, variety *cymbium*, which seems to be the predominating injurious form in that region. These insects are increasing greatly in abundance, with corresponding injury to vineyards. Careful biologic studies of this and related species are under way, and a preliminary manuscript on the three-banded form has been prepared. Experiments in the control of leafhoppers on grape have been directed toward improving

spray mixtures and apparatus, with the view of reducing cost of treatments. It has been found that the period for most effective control varies considerably with the locality and the species, and that recommendations must be based on seasonal development of the species concerned. Results are now being obtained as to the value of dusting for the control of grape leafhoppers, but further observations will be necessary before final conclusions are warranted. Studies of the hibernating habits of the three-banded leafhopper indicate that a large proportion of the adults remain in the vineyards over winter and congregate on various plants, as dandelions, before grape foliage appears in the spring. Preliminary tests show that a large number of these can be destroyed by the application of proper contact sprays or by other methods. Further information is being secured on the rose chafer, a serious pest of grapes in certain parts of the Ohio and Chautauqua-Erie grape belts. The grape-berry moth continues to cause important injury in some vineyards, and experimental work in its control is under way. It has been determined that where previous spraying has been thorough in vineyards control of the berry moth can be secured by a single spray application made about July 10. At this time the use of a combination spray will also be effective against the grape rootworm and grape leafhoppers.

At the Fresno, Calif., station special attention has been given to determining the value in the control of the grape *Phylloxera* of paradichlorobenzene. Unfortunately the results secured indicate that this chemical can not be used with success against this insect.

The Achemon sphinx again appeared in large numbers in vineyards at Madera and Livingston during the summer of 1922, and further experiments were made in testing remedies for its control. A report of these experiments was issued in the January-February number of the Monthly Bulletin of the California State Department of Agriculture. Work on the grape mealybug under way at this laboratory for some seasons has been much reduced, owing to the fact that this insect is now being controlled effectively by parasites.

NUT INSECTS.—Investigations of nut insects have been continued as heretofore. Northern nut insects have been studied at the French Creek, W. Va., station and pecan insects at Brownwood, Tex. During the spring of 1923 an additional laboratory for the investigation of pecan insects was established at Thomasville, Ga., in view of the serious depredations to pecans of certain pests in the Southeast.

At the West Virginia station particular attention has been given to weevils attacking chestnuts and other nuts grown in the northern United States. In cooperation with the Bureau of Plant Industry, experiments are under way to determine possible practical methods of control of chestnut weevils, including spraying with arsenicals. Biologic studies of the so-called cambium curculio, *Conotrachelus anaglypticus*, have been completed and a manuscript prepared for publication. This insect, often mistaken for the plum curculio, occurs frequently on peach, to which it does some injury. It is more particularly injurious by mining around wounds in the bark of many kinds of trees, thereby enlarging and preventing the healing of the injury. Investigations at this station are also being made of certain

miscellaneous weevils, as the plum gouger and the apple curculio, both of which are pests of importance to deciduous fruits.

At the Brownwood, Tex., station further attention has been given to the biology of pecan insects injurious in Texas, and several of these have now been fairly well studied. A report on this phase of the work is soon to be issued. In the field special attention has been given to control of the pecan-nut case-bearer and certain other species of prominence. It appears that best control of the pecan-nut case-bearer can be secured by increasing the number of applications of arsenate of lead and timing them with reference to the hatching period of the eggs. The pecan-nut case-bearer and the green stink-bug continue to be seriously injurious to pecans in the Southeastern States. Studies of these insects are being conducted at the Thomasville, Ga., laboratory, and extensive experiments are under way in pecan groves with various remedial measures. Spraying with arsenicals for the pecan-nut case-bearer during early spring when the larvæ are tunneling the young tender shoots has not given encouraging results. Spraying, however, after the nuts have set has yielded more promising results, and it is believed that a satisfactory method of control can be worked out which will call for a carefully timed spray schedule of about three applications. The injury from the stinkbug can be greatly reduced by the elimination as much as possible of cowpeas in the orchards, substituting as a cover crop the velvet bean. Tests of sprays against the pecan-leaf case-bearer indicate that it can be kept in check by applications of arsenate of lead during the month of August and early September. Tests are being made of the dust method in comparison with spraying in the control of this insect. In cooperation with the South Carolina Agricultural College, studies are being made of the pecan-nut weevil, concerning which complaint has been received from points in that State.

PEACH INSECTS.—The curculio suppression campaign, started in Georgia in 1920, after this pest had caused a loss of over \$2,000,000 to peach growers in that State, has been continued. Beneficial results of the work are being clearly reflected in the yearly increasing quality of the fruit. It was ascertained that a second brood of larvæ of the curculio was during certain seasons responsible for much of the injury to ripening fruit. In cooperation with the Bureau of Plant Industry of this department and the Georgia State Board of Entomology, much experimental work in the field has been accomplished which has resulted in a revision of the spraying and dusting schedule recommended for peaches in Georgia. The treatment now developed is effective in largely preventing injury from the first and second broods of larvæ of the curculio, and also in controlling brown rot and peach scab. The Georgia growers have to an unusual extent followed the directions of the department, with consequent improvement of the crop grown. Tests of the value of spraying or dusting for the control of the curculio after the crop has been harvested have been continued and the results brought together in a manuscript on "Dusting and Spraying Peach Trees after Harvest for Control of the Plum Curculio." It is shown that during periods of unusual curculio abundance this method is an important adjunct in reducing the insect. Attention has been given to ascertaining the value of picking up and destroying peach drops in connection with

the curculio campaign. It has been found that by carefully picking up wormy peaches from under the trees for a period of three to four weeks, a saving of fruit can be effected which, after deducting the cost of the work, amounts to about \$50 per thousand trees. In addition to the saving on the current crop the beneficial results of the work accumulate from season to season. Knowledge of the life history of the plum curculio in Georgia is now very complete and the results of studies of this subject will soon be prepared for publication.

Further tests of paradichlorobenzene for the control of the peach borer indicate that this chemical may be used on peach trees 3 years of age and over without injury to the trees. This materially extends the range of usefulness of this product, which has heretofore been recommended for trees 5 years of age and over.

The good results obtained from the use of lubricating-oil emulsion in the control of the San Jose scale on apple in the Ozarks and elsewhere led to tests of the oil in the control of this pest on peach, in comparison with other standard scale treatments. To date no injury to the trees has been discerned, but further observations will be required before the lubricating-oil emulsion can be recommended for the control of this scale on peach.

APPLE INSECTS.—The work at the Bentonville, Ark., laboratory has been directed largely toward further tests and improvements of lubricating-oil emulsion for the control of the San Jose scale, as this pest continues to be a serious menace to orchards of that section. This oil emulsion has already come into large use in the commercial apple orchards of the Ozarks without any evidence thus far of injury to the trees treated, and has proved to be eminently satisfactory in destroying the insect when applied during the dormant season. Some attention has also been given to the codling moth to round out work already done as a basis for a bulletin on the control of this insect under conditions in that region. Large-scale experimental spraying work was undertaken in the Arkansas Valley at Wichita, Kans., in cooperation with the Kansas Agricultural Experiment Station. Unfavorable weather conditions have greatly interfered with the prosecution of this work. In the Ozark region certain leafhoppers are injurious to apples to an unusual extent, and these have been under investigation for the past two or three years. Sufficient data have been accumulated on these leafhoppers to warrant the preparation of a manuscript for publication. This will include careful biologic studies and methods of control in orchards.

At the Yakima, Wash., station, codling moth investigations have been continued, and special attention has been given to obtaining information on various practical points, as the value of spreaders or stickers, comparative efficiency of spray guns and spray rods, and especially to further perfecting a spraying schedule for the control of this insect under conditions in the Yakima Valley. In addition to arsenate of lead, other arsenicals have been tested, as calcium arsenate, zinc arsenite, etc. A manuscript on the life history of the codling moth in the Yakima Valley is now in course of publication and a Farmers' Bulletin on the control of the insect in the Pacific Northwest has been submitted, which when published will be of much value to the orchardists of the territory mentioned.

The increasing importance of the European red spider, *Paratetranychus pilosus*, has rendered necessary a careful study of this pest. The biology of the mite is being carefully investigated and experiments made in orchards with various sprays for its control. Indications are that a weak lubricating-oil emulsion will prove satisfactory in killing both the eggs and the mites, with little or no injury to the trees or foliage. The lubricating-oil emulsion has also been tested against the San Jose scale and the wintering eggs of the red spider and has proved very effective. A study of a treehopper causing considerable injury to apple by depositing eggs in the twigs has been started.

At the Wallingford, Conn., laboratory the investigations under way for some years in cooperation with the Connecticut Agricultural Experiment Station on the apple maggot were concluded during the fall of 1922, and a report has been prepared giving the results of the studies. It was determined that satisfactory control of the apple maggot can be secured if the fruit and foliage are coated with arsenate of lead during July and August, the period during which the greater number of the eggs are laid. Since this treatment is to kill the adult flies, which travel rather freely from tree to tree, it is important not only that all parts of a given orchard should be treated but also that the orchards in the neighborhood should be properly sprayed. The apple thorn skeletonizer, which has become a serious defoliator of apple in portions of eastern New York and in Connecticut, has been investigated, and a joint bulletin on the insect has been published from the Connecticut Agricultural Experiment Station. Certain other miscellaneous insects have received attention, as the red-banded leaf-roller, false apple red-bug, apple tent caterpillar, etc.

Beginning in the spring of 1923, a deciduous-fruit insect laboratory was established in southern Indiana in cooperation with the Purdue University Agricultural Experiment Station, with headquarters at Vincennes. At this station will be studied the various fruit insects of importance in this rapidly developing fruit region, such as the San Jose scale, the codling moth, the peach borer, a thrips injuring peaches, etc.

INSECTICIDE INVESTIGATIONS.—Investigations of miscellaneous insecticides have been continued at the laboratories in Washington and the near-by field station at Sligo, Md. Studies under way on the chemical, physical, and insecticidal properties of arsenicals, conducted in cooperation with the Bureau of Chemistry, have been concluded and a report on the work published. In cooperation with the Bureau of Plant Industry, a report has been prepared on various plants tested as to insecticidal constituents. The experiments on the effects on honeybees of spraying fruit trees during blossom and as the petals fall have been completed and a manuscript submitted for publication. It is shown that spraying orchards as recommended by entomologists does not result in poisoning bees to any extent. A thoroughgoing study of materials attractive to and repellent to insects has been undertaken, but this work has not proceeded far enough to warrant specific statements as to results.

In the tests of contact insecticides a considerable amount of data has been gathered on various insecticides of this type. In cooperation with the Bureau of Chemistry, material progress has been

made in the development of an insecticide of the general character of nicotine for the control of soft-bodied insects, such as plant-lice. Many compounds are being tested as to their possible toxicity against insects, a partial report of which work has been issued as Department Bulletin 1160. Additional reports on these studies will be made from time to time as the material warrants. In co-operation with the Chemical Warfare Service of the War Department and the scientists of the Federal Horticultural Board, studies are being made of war gases as to their suitability for insect control. At the Sligo, Md., laboratory principal attention is being given to detailed studies of lubricating-oil emulsions at various strengths and for various insects. At this station are also being tested in a field way various insecticidal materials developed by the laboratories in Washington, including many organic substances, chlorinated compounds, coal-tar derivatives and the like.

TAXONOMIC WORK.—The taxonomic work of the office relates mostly to Aphididae and Aleyrodidae and involves determinations of insects of these families received from various sources. Four-hundred seventy-five lots of aphids have been handled and 183 lots of aleyrodids. In order to better understand the species described by various workers in foreign countries, specimens of such species as possible have been borrowed and carefully studied and illustrated. Two specialists in Aphididae visited the office during the fiscal year to avail themselves of the bureau collection. A monograph of the genus *Amphorophora* has been prepared and work is now in progress on the genus *Myzus*.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

This work has been continued throughout the year under the direction of A. F. Burgess.

The field work of the bureau has been carried on in New England in an area about 25 miles wide adjoining the outside border of the infestation. This strip extends through western Connecticut and Massachusetts and central Vermont, and in the northern part of the last State it swings to the eastward and crosses the State of New Hampshire.

In addition to this, cooperative work was carried on with the State of New Jersey from funds made available jointly by the State and the bureau. The infested area covers about 400 square miles and intensive clean-up work was done in this district.

A fund of \$150,000 was made available in New York State early in the spring to carry on survey, experimental, and control work.

The New England States take care of the infestations inside the border area and this work is paid for from State, municipal, and local funds.

The Federal funds have been allotted to four principal projects, viz, supervision, field and laboratory research, quarantine and inspection, and scouting and extermination work. Each will be considered separately.

ADMINISTRATION.—A central office has been maintained at Melrose Highlands, Mass., from which the work is administered throughout the New England States, eastern New York, and New Jersey. A quarantine office is maintained in Boston, Mass., and a suboffice in

Somerville, N. J. The latter is carried on in cooperation with the New Jersey Department of Agriculture, and the gipsy moth field work in that State is administered from it. A laboratory and small storehouse is located at Melrose Highlands, and a large storehouse for housing field equipment and supplies and making repairs on motor vehicles and tools used in field work has been maintained at Franklin, N. H., but has recently been moved to Pittsfield, Mass.

A small storehouse is also maintained at Bound Brook, N. J., in cooperation with that State, where equipment is stored and repairs made.

FIELD AND LABORATORY RESEARCH WORK.—The laboratory at Melrose Highlands, Mass., is headquarters for many lines of experimental work which is conducted in many sections of the area infested with the gipsy moth, and a temporary laboratory is maintained at Somerville, N. J., during the summer.

Two entomologists from the Melrose Highlands laboratory have been carrying on extensive work in Europe during the past year and another has conducted investigations in Japan. The purpose of this work is to study the conditions in the native home of the gipsy moth and secure as much information as possible concerning the natural agencies that assist in its control. Careful search has been made for parasites and natural enemies of the gipsy moth, and several shipments of promising species have been collected and sent to this country for breeding and colonization. The importance of this project can not be overestimated, as it is desired to utilize every enemy of the gipsy moth that can be secured.

During previous years species attacking the eggs, the larvæ, and the pupæ of the gipsy moth and the brown-tail moth have been secured and colonization of these species has been continued systematically throughout the year.

Anastatus bifasciatus has been colonized in all the New England States, 934,000 specimens having been liberated during the fiscal year, and 1,800,000 specimens of *Schedius kuvanae* have also been colonized. These two parasites attack the eggs of the gipsy moth. Twenty-six thousand five hundred and eighty specimens of *Apanteles melanoscelus*, a parasite that attacks the caterpillars of the gipsy moth, were colonized at different points in New England and in New Jersey, and 14,620 puparia of *Blepharipa scutellata* were liberated in Vermont, Connecticut, New Jersey, on Long Island, and at other points in New York State. Field collections of gipsy moth eggs taken from different sections of the infested territory indicate that the parasitism by *Anastatus bifasciatus* averaged from 25 to 30 per cent and in some cases the parasitism by *Schedius kuvanae* ranged as high as 48 per cent. The former parasite survived well in the northern part of the territory, but the latter is not usually abundant in territory much farther north than Boston. In some cases parasitism by *Apanteles melanoscelus* was rather heavy. This was particularly true concerning the second brood of this parasite. Collections of native larvæ in the outside territory indicated that *Compsilura concinnata* had spread as far west as Danbury, Conn., and Milton and Mechanicsville, N. Y. The degree of parasitism by this species in the inside territory was quite similar to that of the previous year. Collections showed that parasitism

by *Blepharipa scutellata* was very heavy in the northern part of the infested territory, particularly at certain points in New Hampshire, west of the Connecticut River. While this insect was recovered, it did not occur in as great abundance in the southern part of the infested region.

Parasitism of the small caterpillars that hibernate in the brown-tail moth webs was slightly greater than last year, and the larvæ this spring were rather heavily parasitized by *Compsilura concinnata*.

The Calosoma beetle and its larva have been reported very abundant, particularly in sections where gipsy moth and brown-tail moth infestations have been heavy, and in such localities the wilt disease has attacked the large larvæ and pupæ and caused heavy mortality.

Careful study of the biology and habits of the different enemies has been undertaken and many new and important facts of scientific importance have been discovered. Some of this information has already been published in bulletins, but further work is required to secure complete data on many phases of the parasite investigations.

Data have been secured for a series of years to determine the effect of defoliation on different species of trees growing under varying conditions. The record of mortality of trees under observation has been made and the retardation of growth due to periodic defoliation is being obtained. This information will be extremely useful as soon as this investigation is complete. Experiments of importance to all phases of the gipsy moth project and some that have a broader application along the line of insect control are under way.

Tests designed to secure more effective methods of control work in the field have been conducted. Aircraft of the heavier and lighter than air types have been tested for dusting infested forests, in cooperation with the United States Air Service, but this work has not yet proceeded beyond the experimental stage. Some experiments have been made with adhesive materials for the purpose of preventing poisoned sprays from washing from the foliage during wet weather.

The application of the results of this experimental work is bound to have a far-reaching effect on gipsy moth control in the future.

QUARANTINE AND INSPECTION WORK.—The area infested with the gipsy moth and the brown-tail moth has been placed under quarantine by the Federal Horticultural Board.

Products likely to carry these insects must be inspected before they can proceed out of the infested area. State quarantines regulate the intrastate movement of such products.

During the year 56,799 shipments have been inspected and certified. The number shows a marked increase over that of the previous year.

SCOUTING AND EXTERMINATION WORK.—The scouting work was carried on during the past year under extreme difficulty. The supply of experienced men was very limited, and it was necessary to train a large force for work in New England and New Jersey. The volume of the work was curtailed in New England on account of heavy snowfall in December, so that much of the scouting in Vermont had to be discontinued earlier than usual.

After the 1st of January snow conditions became bad in Massachusetts and the northern part of Connecticut. In fact, southern Connecticut was the only region in New England where field work could be done to advantage. Certain sections that could not be scouted in the winter were finished early in the spring, and most of the work was completed as planned, except in Vermont.

As a result of this work the following number of towns were added to the area quarantined for the gipsy moth: New Hampshire, 12; Vermont, 33; Connecticut, 9. Three towns in Vermont were dropped from quarantined areas as no infestation was found. Total increase for the year, 51 towns.

Scouting for the brown-tail moth was carried on along the infested border in Maine and New Hampshire by a few men specially detailed for that work. As a result of the inspections made, 2 towns in Maine and 13 in New Hampshire were added to the area quarantined for this insect. Eight towns in Maine were examined and no infestation found and they were released from quarantine. Total increase in area, 5 towns.

The scouting work in New Jersey proceeded about as planned. In addition, 395 acres of tree growth in a number of river valleys and along the Raritan Canal were either cut or thinned. Many of the trees were defective and furnished such convenient hiding places for egg clusters of the gipsy moth that it was necessary to eliminate them in order to insure thorough clean-up work.

The results of the scouting were very encouraging. Fewer colonies were found than during the preceding year, and in large portions of the outlying area no trace of the insect was discovered. In the area north of Somerville, known as the Watchung ranges, small colonies were located in the woodland. This is the most difficult section in which to do thorough work, and intensive spraying operations were conducted during June. All known infestations were sprayed, and owing to favorable weather the work was very effective. The labor supply was very scarce, however, and it was difficult to secure a sufficient number of men to carry through the spraying work. This made the work more difficult to manage and more expensive than usual.

All colonies found in the area scouted in New England were either banded or sprayed during the spring.

GENERAL SUMMARY OF CONDITIONS.—In the territory generally infested with the gipsy moth the area defoliated has been much less than in previous years.

A number of towns have suffered severely, particularly in southeastern Massachusetts and in an extensive area west of Fitchburg, Mass., and throughout several groups of towns west of the Merrimack River in New Hampshire. Defoliated areas of considerable size were also reported near Lake Winnepesaukee, N. H.

The improvement in conditions in the wooded areas was due to considerable nonhatch of the egg clusters above the snowline in many sections and to the increase in the effectiveness of imported natural enemies and disease. The records at the gipsy-moth laboratory indicate that natural enemies have been more numerous and more benefit has resulted from their work than during any previous year.

The brown-tail moth infestation was slightly more severe than during the previous year, and scattering winter webs were found in

the outlying sections of the infested area. In certain sections along the seacoast area in New Hampshire and in the Merrimack Valley considerable defoliation was caused by this insect.

A high percentage of parasitism was found in all localities where sample collections were made, and in a few places the brown-tail moth fungus was present and destroyed large numbers of the full-grown caterpillars.

The gipsy-moth work in New Jersey has been carried through in cooperation with that State and excellent results have been secured. The number of localities where infestations have been found is less than during the previous year and the area infested has been materially reduced.

In New England weather conditions immediately following the hatching period this year were not favorable for the spread of the gipsy moth to new territory. Plans have been made for a thorough scouting of the Hudson Valley by the State of New York, and an additional area between this strip and the infested territory in New England will be inspected by the bureau. From the information secured from this work it will be possible to determine the most favorable area in which to locate a barrier zone against spread toward the west between Long Island Sound and the Canadian border.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

W. R. Walton has continued in the leadership of this section of the bureau's work.

EUROPEAN CORN BORER.—There have been no developments of great importance in the European corn-borer situation during the past year. The extent of the infestation in northwestern Pennsylvania, northern Ohio, and southeastern Michigan has remained substantially as reported at the corresponding season last year. In the areas mentioned a slight spread into contiguous territory has been noted, but the intensity of infestation in these regions has not increased materially and amounts on the average to about 1 and not to exceed 3 per cent of the corn plants grown within the areas. The highest infestation noted was in the immediate neighborhood of Ashtabula, Ohio. As yet, the insect has done no perceptible damage throughout this region.

As noted in the last report, a field laboratory has been located at Sandusky, Ohio, where investigations are being carried on in cooperation with the Ohio State Experiment Station for the purpose of collecting seasonal biological data, determining the most immediately effective measures for control, and the varieties of corn best suited for culture in that region under conditions of corn-borer infestation.

In the area of infestation immediately surrounding Buffalo, N. Y., a very considerable spread eastward was noted during the summer and fall of 1922. This has been largely in the direction of the prevailing winds, and probably was due to the migration of moths either from the Canadian area or perhaps from the Indian reservation which forms a part of the American area of infestation, and where it has not been possible to induce the corn growers to make any effort to control the pest. Although this area of infestation has increased materially in extent, the amount of damage inflicted has been com-

paratively slight. In eastern New York, in the vicinity of Schenectady and Albany, the area has grown slightly, but the damage here continues to be trifling.

Scouting operations conducted throughout the New England area during the summer of 1922 developed the fact that the corn borer had invaded eastern Rhode Island and had spread northwestward up the Merrimack Valley into central New Hampshire. It has also become firmly established in York County, Me. It is believed that the insect probably has reached its limit of destructive distribution in central New Hampshire, as practically no corn is grown to the northward of the present area, which is bordered by the White Mountains. On the other hand, it is probable that the insect will continue to spread into southwestern Maine, and that it may seriously invade the sweet-corn growing area adjoining the region of present infestation. The pest continues to be seriously injurious in the region immediately surrounding Boston, Mass.

During the year a new publication, *Farmers' Bulletin 1294*, has been published, embodying the immediately applicable results of the European corn borer investigations which have been carried on for the past four years. A complete technical report on the progress of these investigations is in preparation.

Excellent progress has been made in the work of introducing the insect enemies of the corn borer from Europe, and during 1922 more than a million specimens of one species were liberated in the New England area.

Arrangements have been perfected with the Canadian Department of Agriculture to supply colonies of this parasite for possible establishment in the Dominion in southern Ontario, where the corn borer occupies a large part of the peninsula bordered by Lakes Ontario, Erie, and Huron. An additional parasitic species which first was liberated in Massachusetts during the fall of 1922 has been recovered from the field in several different localities in New England, and the establishment of this species there now seems assured. Several other promising parasites are being reared, both in New England and in France, and it is confidently expected that these species will be propagated in sufficient numbers to insure them an excellent opportunity to become established in this country.

Some of the States which have been cooperating financially in the work against the European corn borer have failed to appropriate funds for the continuation of this work during the present fiscal year, a fact which may interfere somewhat with the effectiveness of the combat against this pest. An additional appropriation of \$25,000 which was granted by Congress and which became available July 1, 1923, will not be entirely sufficient to compensate for the reduction of State assistance in this work.

ALFALFA WEEVIL.—The continued spread of the alfalfa weevil throughout the Great Basin States and the increasing damage which it is causing in some of these States, notably Idaho, have caused great apprehension, especially throughout the more newly infested regions. The insect now occupies practically all the alfalfa-growing regions of Utah and Idaho, and is found in parts of Colorado, Wyoming, and Nevada. It has also been discovered in eastern Oregon and more recently has been reported from Sierra County,

Calif. An efficient means of control has been evolved by the bureau in the use of an arsenate of lead spray which usually gives satisfactory control when applied once during the season. In southwestern Idaho, however, it was discovered that two sprayings are necessary in order to obtain satisfactory control, because of the fact that the weevil continues laying eggs throughout a longer period than elsewhere. The one thing which apparently is most urgently needed in the aid of artificial control of this pest is some more efficient means of placing the available information on control before the alfalfa growers who are most vitally concerned. Some of the States which have been carrying on this educational work have been compelled to restrict or discontinue it through lack of funds. This has been the case notably in Idaho, and it is hoped that some means may be found for the continuation and elaboration of this type of work in connection with alfalfa weevil control.

Arrangements have been perfected for resuming the introduction of the insect parasites of the alfalfa weevil from Europe. An expert who was dispatched to France for that purpose more than a year ago recently has returned after accomplishing his mission, and shipments of parasitic material are beginning to arrive in this country. It is hoped by these means to supplement the good work of a parasite already introduced from France, and thus eventually to restore the balance of nature and secure natural control.

GRASSHOPPERS.—Grasshoppers have continued to be seriously injurious in the spring wheat region of the Northwest, and especially severe outbreaks have occurred in northern Montana and throughout Wyoming. Local outbreaks of these and similar insects have occurred in eastern Utah and northwestern Colorado, where the bureau has been active in lending its aid through the services of a corps of trained experts, whose headquarters have been located at Billings, Mont. Progress has been made in the standardization of the poisoned baits and in the coordination of the plans for control between the various State agencies and the entomological workers of the Dominion of Canada in the neighboring prairie provinces. It is estimated that campaigns in which the bureau has assisted in North Dakota, Montana, and Wyoming have resulted in the saving of about 10 per cent of the wheat crop throughout the areas involved.

A serious outbreak of the lubber grasshopper occurred in west-central Texas during the summer of 1923, during which considerable damage was done. The farmers found it difficult to poison because of the suddenness of the attack and the fact that sufficient arsenic was not locally available.

A serious and widespread outbreak of grasshoppers occurred in the Klamath Lake region on the southern border of Oregon and the northern edge of California. Experts of this bureau were dispatched from Sacramento, Calif., and Forest Grove, Oreg., to assist the local authorities in securing control. A very considerable saving of crops resulted from the work done. If this pest is to be permanently controlled, however, a thorough study of the whole problem will be necessary, and because of the fact that this problem is of an interstate character and involves public lands within the breeding grounds of the pest, it seems proper that the Federal Government should initiate studies looking toward the control of grasshoppers in this severely infested region.

THE SOUTHERN CORN STALK-BORER.—This insect, which is closely related to the larger corn stalk-borer and the sugar-cane moth borer of the Southeastern and Southern States, has become increasingly injurious and abundant during the past two years throughout the Big Bend country of Texas and the river valleys of eastern New Mexico. Investigations have shown that the counties of El Paso, Culberson, Jeff Davis, Presidio, and Brewster, in Texas, are most seriously involved. The pest has been reported as so abundant and destructive in the Pecos Valley as to cause the growing of corn to be practically discontinued there. The species apparently is of tropical origin, but has been found to occur at elevations exceeding 5,000 feet. The eastern edge of the infestation in northwestern Texas is separated from the western border of the corn-growing area of the State by a strip of land about 25 miles wide, in which no farming is done. As this species evidently is a highland form and similar in that respect to the Colorado potato beetle and the Mexican bean beetle, it seems altogether possible that it has potentialities for damage throughout the Corn Belt which may prove formidable, should it migrate to that region. A close study of the species, therefore, is being made.

WHEAT STRAWWORM.—The wheat strawworm is distributed throughout the wheat-growing regions of the United States, and ranks high in importance as an insect enemy of wheat, often destroying whole fields of this crop, especially in the spring wheat region. As a result of studies carried on during the past few years, with Charlottesville, Va., as a center, it has become possible to publish during the past few months a brief Farmers' Bulletin, No. 1323, which affords practical information regarding the control of the pest.

OTHER INSECTS.—A number of other projects are under way. The corn earworm, which is the same insect as the cotton bollworm and the tomato fruitworm, is from the fact of its many food plants a most difficult insect to control. Possibilities of cultural methods are being studied under this section and a cultural means of control discovered has proved satisfactory in the Atlantic coastal plain region. The webworms, which normally inhabit grasslands, frequently damage corn to a serious extent when grasslands are broken up and planted to corn. Studies of these insects have been continued with measurable success in the region of which Knoxville, Tenn., is the center.

STORED-PRODUCT INSECT INVESTIGATIONS.

Investigations in this section of the bureau work have continued under the leadership of Dr. E. A. Back.

BEAN WEEVIL INVESTIGATIONS.—The biological studies of the bean weevils, *Bruchus obtectus* and *Bruchus quadrimaculatus*, which have had the leading place in the investigation work being conducted with headquarters at Alhambra, Calif., have been subordinated during the past year to a study of these pests in the commercial bean fields of California. Studies of the varietal susceptibility of the commercial bean varieties have been continued along with a more intensive study of the possibility of controlling field infestations by the proper timing of planting and harvesting and the intelligent use of trap crops.

Special attention has been given to a study of the handling and storage of beans and peas in commercial bean warehouses with a view not only to eliminating infestations once crops have been gathered but to determining the connection between careless and unintelligent warehouse methods and the increasing difficulty of growing crops of beans free from infestation. Satisfactory progress is being made, and this work of the bureau has received the commendation of the California Bean Growers' Association and the bean weevil committee of the Modesto (Calif.) Chamber of Commerce.

INSECTS ATTACKING GRAIN AND GRAIN PRODUCTS.—The investigation of insects attacking corn, wheat, and other grains and mill products has been continued during the past year at Washington and at Thomasville, Ga.

At Washington studies of the biology of the rice weevil, *Sitophilus oryza*, and the granary weevil, *Sitophilus granarius*, have been finished for the present and the results prepared for publication. Studies of the biology of the cadelle, *Tenebroides mauritanicus*, and the mealworms, *Tenebrio obscurus* and *Tenebrio molitor*, are nearing completion and the data are being prepared for publication. A study of the biology of other grain pests, more particularly the flour beetles, *Tribolium* spp., is under way.

In southern Georgia, with headquarters at Thomasville, the work reported upon last year has been continued with good results. Special studies have been made during the past year of the relationship existing between the location of cribs and other storage centers and the degree of infestation in other parts of the field. While these studies are far from complete, the data already secured indicate that there is a good basis for the belief that the migrations of the rice weevil from storage centers are responsible for much if not all of the widespread and potentially serious infestation found in the field in corn at the time of harvest. This is a continuing work and will require more funds before it can be determined whether field infestations can be controlled by community effort in the destruction of insects in storage.

DRIED FRUIT INSECTS.—Intensive studies have been made at Fresno, Calif., of the Indian-meal moth, *Plodia interpunctella*, and of the dried-fruit beetle, *Carpophilus hemipterus*, two serious pests of dried fruit, and data concerning their biology are being prepared for publication.

INSECTS ATTACKING MEAT.—The investigation of insects attacking meats, particularly cured meats, begun two years ago, was interrupted June 30 for lack of sufficient funds. Good progress has been made during the past year and many new scientific data secured. Technical papers summarizing these data have been prepared on the cheese and ham skipper, *Piophilus casei*; the red-legged ham beetle, *Necrobia rufipes*; and the larder beetle, *Dermestes vulpinus*.

FABRIC AND HOUSEHOLD PESTS.—The investigation of fabric pests has been conducted at Washington and has centered in a study of the biology of the clothes moth *Tineola biselliella* and the carpet beetles *Anthrenus fasciatus* and *Attagenus piceus*, together with numerous tests made of cloths that have received so-called moth-proofing treatments, in cooperation with fabric concerns and the

Insecticide and Fungicide Board. It is natural that this phase of the bureau's work should be specially active during a year when the interest of the fabric industry of the country has been aroused by the possibility of rendering woolen fabrics immune to clothes moth attack. Farmers' Bulletin 1353, Clothes Moths and Their Control, and Farmers' Bulletin 1346, Carpet Beetles and Their Control, are in course of publication, and data on the biology of *Tineola biselliella*, *Anthrenus fasciatus*, and *Attagenus piceus* are being prepared.

COLD STORAGE FOR THE PREVENTION OF LOSS BY INSECTS.—The aim of this investigation is to determine the most practical temperature at which commodities subject to insect destruction in storage can be held to render them free from living pests. Four cold storage units have been secured for laboratory tests. Data are accumulating in the bureau files which will be supplemented by others secured in commercial storage plants. The rapid increase in the use of cold storage for the preservation of commodities has opened a new and most practical field for investigation. At present the demands for information concerning the effect of cold storage temperatures on the insects in stored commodities can not be met for lack of data.

EXPERIMENTS WITH WOODS OF INSECTICIDAL VALUE.—The completion of experiments to determine the value of cedar chests made of the red cedar, *Juniperus virginiana*, reported upon last year, has led manufacturers to inquire concerning the possible value of other woods when made into chests and closets, from the standpoint of moth protection. Woods of the southern or white cedar, the redwood, and camphor are being tested. Woods of the Spanish cedar, *Cedrela odorata*, and Port Orford cedar will be tested. The possible value of the essential oils of these woods as well as those of the eucalyptus and pine when used to impregnate wardrobe linings in which fabrics are stored is being tested.

FUMIGATION.—The investigation of the value of fumigation in the prevention of losses through insect attack in warehouses continues to be an important phase of the work of the bureau. Industries throughout the country are calling upon the department continually for information regarding the protection by fumigation of stocks of raw wool, grain, grain products, beans, cowpeas, candies, meats, hides, brushes, fabrics, furniture, and a long array of other susceptible raw and manufactured products.

INSPECTION AND INTELLIGENCE SERVICE.—Cooperation with the Army and Navy has been continued in the way indicated in last year's report. This service during the past year has been directed more largely toward furnishing the Navy with information regarding the protection of large consignments of brushes, flags, sweaters, and other wearing apparel from moth attack.

TROPICAL AND SUBTROPICAL FRUIT INSECTS.

Investigations of tropical and subtropical fruit insects have been carried out under the direction of Dr. A. L. Quaintance as formerly.

CITRUS FRUIT INSECTS.—At the Florida citrus insect laboratory at Orlando special attention has been given to the so-called Bordeaux-oil-emulsion spray for use in preventing damage by citrus insects and

diseases. This work, carried out in cooperation with the Bureau of Plant Industry, has been successful and the results have been brought together for a publication on the subject. Two new oil emulsions have been tested which give much promise as treatments not only for insects attacking citrus, but also for those attacking deciduous trees. Experiments in the use of dusts for the control of the orange rust mite have been completed and the results have been published in the local horticultural press. A paper giving results of several years' study of the rust mite is in course of preparation and will prove of much value to citrus growers. Further data on the biology of the Florida red scale have been accumulated and it is believed that these studies will soon permit of a complete account of this very important citrus pest.

The continued importance of the citrus thrips in California led to the establishment of a laboratory at Lindsay in cooperation with the Tulare County Citrus Growers' Exchange for a special investigation of this insect. Attention is being given to the biology and ecology of the citrus thrips, and extensive experimental work in the field with various spray materials is being done to test their relative efficacy. Since this station was established in March, 1923, there has not been sufficient time for definite results in the biologic or field experimental work. The indications are that spray materials in general use on citrus will, when applied in the proper manner and at the proper time, be effective in the control of the citrus thrips. Spraying for the thrips, however, must be considered in conjunction with spraying for other insects, such as the Citricola scale. Since the cost of spraying amounts to about \$10 to \$15 per acre for a single application, and since probably two applications for both scale and thrips control are about the maximum that can profitably be given, special attention will be directed to the development of economical and effective methods for the control of the two pests by one and the same treatment. Further experiments with nicotine dusts for the control of the thrips confirm earlier conclusions that this was not effective.

FRUIT FLIES IN HAWAII.—The investigations and control of fruit flies in Hawaii have been continued in cooperation with the Federal Horticultural Board. The plant quarantine regulations of the board require the inspection of fruits and vegetables for shipment to the mainland, and supervision over plantations and packing sheds is maintained. In connection with this work 2,330 shipments of fruits and vegetables for export to the United States have been inspected and 670 packages, mostly bunches of bananas, were rejected as unfit for shipment. The number of packages certified for shipment was as follows: 215,555 bunches of bananas, 11,304 crates of pineapples, 5,659 crates of taro, 389 bags of coconuts, 149 crates of ginger root. As heretofore, daily records of parasitism of the Mediterranean fruit fly, *Ceratitis capitata*, by the four introduced parasites have been made, as well as the amount of infestation by the fruit fly in different host plants. Much progress has been made in the life history studies of three bruchids, *Bruchus prosopis*, *Mylabris sallaei*, and *Caryoborus gonagra*, all of which attack the seed pods of the algaroba, *Prosopis juliflora*. Several parasites attack these bruchids, four species of which were introduced into the island from Texas. These parasites are being

studied with the view to their better utilization. Extensive experiments on the effect of cold-storage temperatures on the fruit fly in fruits have been undertaken. Information of this character will be useful in connection with questions of exports.

FRUIT FLIES, CANAL ZONE.—Investigations at the Canal Zone station have been directed to obtain further information concerning various subtropical insects likely to be introduced into the States. In co-operation with the Federal Horticultural Board, close scrutiny is maintained to insure, if possible, that no foreign insect effects establishment in the zone as a result of the large amount of traffic from all parts of the world which moves through the canal.

MANGO AND AVOCADO INSECTS.—Studies of subtropical insects other than citrus insects have been continued at the Miami, Fla., station, special attention being given to the red spider of the avocado, avocado white fly, avocado leaf thrips, papaya fruit fly, and others. The red spider has proved to be a pest of major importance in all sections where avocados are grown in Florida. The biology of this mite has been carefully studied as a basis for control operations and a preliminary report has been issued. As a treatment for the mite a mixture of sulphur and dehydrated lime has proved to be superior as a dust to pure sulphur, and obviates danger of occasional burning of foliage under high temperature. Studies of the avocado leaf thrips have been comprehensive and a manuscript on the insect is in the course of preparation. This insect can be well controlled by the use of lime-sulphur, nicotine spray, or a nicotine-soap spray. A nicotine dust is also quite efficient in destroying the thrips. The papaya fruit fly continues to be difficult to control in view of its habit of boring into the fruit. By the use of cloth and paper bags applied at the proper time a large percentage of injury by this insect can be avoided. Several mango insects are also being studied, as the mango shield scale, the blossom *Anomala*, the tessellated scale, Florida red scale, and the like.

CAMPHOR SCALE.—Work on the camphor scale, a recent introduction from Japan, is being vigorously prosecuted in cooperation with the Louisiana State Department of Agriculture, with headquarters at New Orleans. This insect is apparently rapidly increasing in New Orleans, where it was first discovered several years ago. It is also present in the wooded country about 15 miles west and in the swamps just north of the city. Two infestations at Hammond and Baton Rouge, La., previously reported, are believed to have been eradicated. The insect has been found in a small citrus nursery at Lake Charles, La., and steps have been taken to eradicate this infestation if possible. In Alabama the insect appears still to be confined to the general region around Grand Bay and to a single citrus orchard in the vicinity of Mobile. The scale has also been found at Alvin, Tex., on the site of an old nursery, from which it is not improbable the insect has been shipped and become established at other points in Texas and perhaps other States. The Texas infestation, however, is not especially intense and the insect apparently is not so successful in maintaining itself in that State as in the more humid region around New Orleans. So far as known no additional infestations in Mississippi have been discovered other than those previously reported, namely, at Hattiesburg, Pass Christian, and Biloxi. The infested plants in every instance were

destroyed and it is likely that under the vigorous system of inspection and treatment practiced in Mississippi no camphor scale now exists in that State.

Special work is being done to develop efficient and economical sprays for the control of the camphor scale on its various host plants. Many tests have been made to ascertain the proper strength of and exposure to hydrocyanic-acid gas for the disinfection of nursery stock shipped out of the New Orleans area. All regulatory and other work designed to prevent the spread of this pest is in the hands of the officials of the various States interested. Special attention is being given to this work by the Louisiana State entomologist in view of the general occurrence of the pest in New Orleans and the amount of florist and nursery stock being shipped out.

GREENHOUSE INSECTS.—The studies of greenhouse insects under way for some years have been continued and enlarged to meet the demand for information from florists and others concerning insects attacking plants grown under glass. The investigation of the strawberry rootworm, an insect injurious to roses, has been completed and a satisfactory method of control determined, which has been published in Farmers' Bulletin 1344. The insects attacking chrysanthemums have been studied and a publication giving advice on this subject distributed during the spring. Experiments in the control of *Chrysomphalus aonidum* on Kentia, Phoenix, sago palm, and rubber have been carried out, and it has been found that fumigation, using 1 ounce of sodium cyanid per 1,000 cubic feet of space, will give 100 per cent control without injury to the plants, provided the plants are properly shaded before and after fumigation. Tests of many different insecticides on this scale have been made, with the result that lubricating-oil emulsion has proved to be very satisfactory for its control, producing a mortality of 78 per cent. A second treatment with the emulsion however gives a control of approximately 100 per cent. Numerous other important studies are in progress, as experiments in the fumigation of Dutch bulbs; tolerance of plants to hydrocyanic-acid gas; control of earthworms with contact insecticides; liquid cyanid experiments, etc.

VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS.

Work on the project of vegetable and truck-crop insects has been continued as formerly under the direction of Dr. F. H. Chittenden. The Mexican bean beetle and the sweet-potato weevil have been the subjects of special lines of investigation, the former with a view to the discovery of an insecticide which will effectively destroy the insect without at the same time injuring beans and other leguminous crops affected, the latter with special reference to its eradication in Mississippi, Alabama, Georgia, and certain sections of Florida.

THE MEXICAN BEAN BETTLE.—The Mexican bean beetle has continued to extend its northward range. A slight extension was noted in Georgia in the counties southeast of Atlanta. The Thomasville infestation has apparently not changed. While it is hoped that such conditions as low altitudes, warm weather, and the absence of mountains are unfavorable for the development of this pest, it is still too early to draw definite conclusions. The extension of infested territory includes two new States—Mississippi (one county) and Virginia (two

counties). The insect has been reported in Meade County, Ky., on the Ohio River opposite Indiana. Throughout the area known to be infested in 1922, the injury has been more or less spotted in intensity. Heavy injury has been reported from growers in areas known to be suffering relatively little as a whole. Numerous requests for assistance have been received from central Kentucky, Virginia, and North Carolina, showing that the insect is attracting greatest attention along the northern edge of the infested territory. Tests with arsenicals and other insecticides are being conducted at the main laboratory in Alabama and at a substation in Tennessee. The combinations which gave the most promise during 1922 are as follows: As a wet spray, 1 pound of magnesium arsenate to 50 gallons of water; as dusts (1) 1 pound of magnesium arsenate to 4 or 5 pounds of air-slaked lime, (2) 1 pound of tricalcium arsenate to 9 pounds of hydrated lime, (3) 1 pound of calcium arsenate, 1 pound of dusting sulphur, 4 parts of hydrated lime. The calcium-arsenate-sulphur-lime dust which was developed by the Alabama Experiment Station has given good results in tests performed by the Bureau of Entomology. During the late summer of 1922 several shipments of *Paradexodes epilachnae* Aldr., a tachinid fly parasite of the bean beetle, were received from Mexico. About 300 individuals were bred from native larvæ of the bean beetle, but most of these issued and died in the late fall after the bean beetle had stopped breeding. An agent of the bureau is now in Guatemala and Mexico searching for additional parasites of the bean beetle. It is planned to make additional shipments of this parasite in an endeavor to bring about its establishment in the southeastern United States.

OTHER INSECTS INJURIOUS TO PEAS AND BEANS.—Work on the pea aphid has been continued on cannery peas in both Wisconsin and California. Experiments with nicotine dust, using both the ready-prepared dust and a machine which mixes and applies the dust at one operation, have given some promise. Tests are also being made of calcium cyanid as an open-air fumigant, but have not been completed. Studies on the migration of the aphid and the farm practices in more heavily injured districts are being conducted in cooperation with various State entomologists. Investigations on the control of the bean fly or seed-corn maggot are being continued in New Jersey. Further tests for the control of the bean leaf-beetle and bean aphid are being made. Experiments for the control of the corn earworm, which has attracted unusual attention as a pest of cannery beans, are being conducted in Maryland.

SWEET POTATO WEEVIL ERADICATION AND CONTROL.—The sweet potato weevil eradication campaign has been continued successfully in Mississippi, Alabama, Georgia, and portions of Florida. During the early summer inspection no infestations were found in the formerly infested region of Charlton County, Ga., and Baker County, Fla., but several farms with unsatisfactory histories are being closely watched. Thorough inspection in territory surrounding the old infested area has not revealed a single new infestation. The reduction in the number of dangerous farms permits a closer supervision of this territory, and the inspectors have been able to keep close check of infested and suspicious stocks. In the infested area near Lily, Fla., the eradication project has been continued successfully without supplying the growers with clean planting stock. All seed materials

selected by inspectors are taken from farms under supervision and planted in approved fields. This method is preferred by the farmers, since they are not dependent upon outside sources. The final success of this method will be of great importance in proving the direct value of cultural efforts on the part of individual growers. In Alabama a small new infested area was discovered in a fishing settlement on the Gulf of Mexico. This infestation, the only one known in the State, does not immediately threaten the commercial sweet-potato growing areas, but repressive measures are being applied. The number of infestations in Mississippi has increased to some extent during the past year, and insufficient personnel, coupled with high winter temperatures which favor the growth of volunteer sweet potato, is responsible for the increased infestations. In Pearl River County, Miss., the planting of "outlaw" slips is responsible for the extension of the infested area. An interesting occurrence of the year was the discovery of an infestation in Stephens County, Okla. The close cooperation of the State plant boards of Mississippi, Florida, Alabama, and Georgia has continued to facilitate the eradication campaign.

INSECTS INJURIOUS TO POTATO, TOMATO, AND RELATED CROPS.—Tests for determining the minimum application of various arsenicals for the control of the Colorado potato beetle are being conducted in Louisiana. Attempts to control the tomato suckfly, *Dicyphus separatus* Uhl., in Texas have led to the conclusion that from 3 to 5 applications of a 3 per cent nicotine sulphate dust are required. Further work with improved dusts is planned. Plantings of trap crops of sweet corn for the tomato fruitworm were found to be ineffective in Louisiana. The only promising remedy for this insect consisted in keeping the tomato foliage well covered with arsenicals during the fruiting period, a difficult operation in regions of frequent rains. The Australian tomato weevil, which was recently discovered in southern Mississippi, has been found to be more widely distributed over the Gulf Coast region than had been anticipated. It has been determined to be, in restricted localities, a severe pest on turnips and tomatoes. Investigations are still under way on the potato leafhopper and potato aphid.

CUCURBIT INSECTS.—Studies on the striped cucumber beetle are being continued in Wisconsin and Virginia. The value of nicotine dust for the control of this pest has been proved by additional experiments, and at the present time improved dusts are being tested against it in the hope that various combination treatments may be developed. Nicotine dust has also been tested against the melon aphid in Maryland and Texas and it has been found to give a much more satisfactory control than the nicotine soap sprays. The belted cucumber beetle, *Diabrotica balteata* Lec., has been studied in Louisiana, where this insect within the past few years has developed into an important and threatening enemy of beans, cucurbits, and other vegetables.

INSECTS INJURIOUS TO CABBAGE AND OTHER COLE CROPS.—Experiments in the control of various insects affecting cabbage and related crops have been conducted in South Carolina and Louisiana. Nicotine dust has been found to control effectively the turnip aphid, *Rhopalosiphum pseudobrassicae*. Insecticide tests are also being conducted against the cabbage aphid and the harlequin cabbage bug.

A study has been conducted on the distribution and habits of the cabbage flea-beetles and some species have been the subject of special investigation in Louisiana. Nicotine dust gives some promise as a control means.

INSECTS INJURIOUS TO STRAWBERRIES.—Investigations in the control of the strawberry weevil have been continued in New Jersey and South Carolina, and in both States the value of proper arsenical combinations with sulphur applications has been demonstrated. In Louisiana additional studies have been conducted in the control of the strawberry flea-beetle, *Haltica litigata* Fall, which has within the past few years become a serious pest on strawberries in that State. Further work is being conducted in the control of the red spider on strawberry in Louisiana. It has been learned that the unfavorable weather conditions existing in the spring render it almost impossible to control this insect at the time when it is in greatest abundance and most injurious to strawberry. Biological studies, however, indicate that it may be possible to obtain practical control by application of insecticides in the fall.

SUGAR-BEET INSECTS.—Work on the curly-top leafhopper in co-operation with the Bureau of Plant Industry has been continued in southern California. Further studies in the life history of this insect and the relation of wild food plants to its destructive abundance are being followed. The production of disease-resisting strains is still receiving attention and some promising preliminary results have been obtained. Life-history studies of the beet army-worm in its occurrence on peas in California are being continued.

NICOTINE DUST INVESTIGATIONS.—The importance of nicotine dust as a means for the control of various truck-crop insects has led to a continuance of studies of this insecticide. The relation of various carriers to the effectiveness of nicotine dusts is being tested in California, Louisiana, Maryland, Virginia, and Wisconsin. Such tests have considered the mechanical value of different compounds, in addition to their absorptive qualities and the varying rates at which they cause volatilization of the nicotine.

GENERAL TRUCK-CROP INSECTS.—In South Carolina the Porto Rico mole cricket, recently introduced in that State, has continued to be the subject of investigations with poisoned baits with gratifying success. In Louisiana additional work has been conducted on the southern green plant-bug, *Nezara viridula* L., but a perfectly effective method of control has not yet been developed. Work has been done on the control of the onion thrips in Texas, with especial attention to the value of nicotine dust as a remedy, and additional work has been conducted on the onion maggot in its occurrence in Wisconsin. Some work has been begun and will be continued on dusting with calcium arsenate or arsenate of lime on a number of insects in comparison with other arsenicals and nicotine dust, since it contains a stronger arsenic content than lead arsenate and can be obtained cheaper. As soon as it is on the market more extensively it will probably replace lead arsenate at nearly half the cost. The results thus far obtained are very promising.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Dr. W. D. Hunter has been in charge of these investigations as formerly.

COTTON BOLL WEEVIL.—The principal activities have centered around the study and further improvement of the calcium arsenate dusting method of boll-weevil control. Severe weevil infestation in 1922 caused a more extensive commercial use of this method than ever before. A special study was made of the results secured by approximately 1,100 farmers, who dusted altogether 125,485 acres of cotton. These farms were quite uniformly distributed over practically all of the cotton States and represented every type of condition under which dusting was conducted. A summary shows that slightly over 96 per cent were successful in controlling the weevil to the extent of making the operation profitable. The average increase in yield upon these farms was 339 pounds of seed cotton per acre. The average cost of the season's application was \$4 per acre.

The increase in the use of calcium arsenate developed a shortage of this material. This resulted in the appointment of a committee from various Federal agencies, such as the Geological Survey, Bureau of Mines, Bureau of Chemistry, and Bureau of Entomology, as well as representatives of producers and consumers of arsenic in various lines, for a thorough study of the calcium arsenate situation. Undoubtedly such broad consideration of all angles of the problem of arsenic supply and demand will do much to stabilize further development and to make supplies available for the farmer as needed.

Special studies have been conducted along the line of determining the minimum yield per acre upon land where dusting with calcium arsenate would be justified by results obtained. Approximately 1,000 tests affording a comparison between cotton upon which weevils had been allowed to propagate without hindrance and other cotton, strictly comparable, but from which the weevils had been practically eliminated by poisoning, were summarized. It has generally been found that the season's dusting upon any particular farm should cost not to exceed the current value of 100 pounds of seed cotton per acre, in order to make a profit by the dusting method. After making all computations in this regard, the recommendation for dusting has been modified to include all lands having a potential yield of over one-third bale per acre and suffering fairly severe weevil infestation.

The plat tests on methods of poisoning at Tallulah, La., have been continued. The study on season of poisoning, with particular reference to comparisons between early and late-season applications, was practically completed, and the results are being put into the form of a bulletin for publication.

The unusual interest in sweetened poisons for weevil control necessitated carrying out large series of tests on this method, and many such preparations were studied. So far the results have not been sufficiently definite to warrant recommending the general use of such preparations by planters, but the studies are being continued in the hope of developing some way in which they can be used to advantage.

The work in developing new types of equipment and improving existing models has been continued. It has been found that as cotton dusting extends to new districts, new problems of application from

the mechanical viewpoint are met, which necessitate either producing new types of machinery or modifying existing types. Probably the most important development of the year along this line has been the further improvement of the saddle dust-gun to the point where it is now a commercial success. Particular attention is also being devoted to the problem of developing dusting machinery which will permit daytime operation.

Chemical studies in cooperation with the Bureau of Chemistry and the Insecticide and Fungicide Board have been enlarged and include not only the improvement of calcium arsenate but also the possibility of finding an even superior chemical for this purpose. One of the most important discoveries of the year was the fact that there is a very distinct chemical relation between the composition of the dew on the cotton plant and the action of certain insecticides. It was found that the dew on cotton plants is strongly alkaline, and this discovery opens up many important possibilities while explaining some apparent inconsistencies in the results of certain chemicals previously studied.

Other correlated problems which have received attention include the electrical charging of poison dust and the classification of insecticides on the basis of physical characteristics.

The invasion of the extreme southeastern States by the weevil brought the species into contact with new conditions which will necessitate some modifications in the problem of control. Therefore investigations in cooperation with the State of South Carolina were inaugurated in a comparatively small way at Eastover and Sumter, S. C., but in the spring of 1923 a more elaborate station was opened at Florence, S. C., at which place an investigation of the entire weevil situation in the southeastern territory was begun. Careful experiments to test the different methods of weevil control advocated by agencies outside of this department as well as the dry calcium arsenate method were started.

The relationship between cotton dusting and aphid injury to the cotton plants was further studied. It was at first thought that the reason for the abundance of aphids was the poisoning of the predatory enemies of this species. Experiments to test this idea have not been conclusive. It has been shown, however, that the cotton aphid can be controlled by the use of nicotine dust with a hydrated lime base used at the rate of 8 or 10 pounds per acre when the dust contains 2 to 3 per cent nicotine. Practically complete control can be secured from a single application.

In the fall of 1922 experiments in the use of airplanes for the purpose of applying insecticide dusts were inaugurated. The airplane applications at that time were for control of the cotton leafworm, but many points were determined which apply to the problem of weevil control.

In the spring of 1923 experiments were started in direct control of the boll weevil by means of airplanes. The results so far have shown quite definitely that airplanes can be used economically to control gross feeding insects such as the leafworm, but it has not been determined as yet that they can be used for boll-weevil control.

Studies on hibernation, together with correlated records on spring emergence and distribution, have been continued and in the spring of 1923 reached the point where it was possible to bring the records

together for publication. A total of nine years' observation at Tallulah have been accumulated, including both annual comparisons and special studies to determine the relative importance of different locations as regards weevil shelter. These records are particularly important in connection with the Florida method of weevil control, since this method is largely based on accurate hibernation records.

The question of the effect of the use of poisons for boll-weevil control on adjacent bee colonies was investigated in the vicinity of Tallulah. It was found that no important mortality of bees resulted in any instance from the application of calcium arsenate to cotton plants. It therefore appears that there is no reason to believe that bee colonies would be seriously affected under the conditions existing at Tallulah. However, cotton does not appear to be an important honey plant at Tallulah, and it is possible that different results might be secured in other districts.

The annual dispersion of the weevil was determined in the fall of 1922 as usual. The summary showed that only 4.01 per cent of the cotton crop of the United States is produced in the territory not yet infested.

The usual outbreak of the cotton leafworm in 1922 presented several new problems of control, particularly in relation to the insecticides to be used. Some special studies were conducted on this point and are being continued.

TOBACCO INSECTS.—The experiments begun last season in the Burley district in Kentucky upon the control of the tobacco hornworm met with a most flattering reception. The Burley growers knew but little about modern methods of controlling the hornworm, and they are rapidly adopting the cheaper and more thorough methods advised by the bureau.

True wireworms cause an annual loss of from \$1,000,000 to \$2,000,000 to the Burley tobacco growers. In a series of five careful experiments the nitrobenzene-flavored bait reduced the infestation by as much as 50 to 60 per cent. This promising line of work will be enlarged next season.

A poisoned bait using nitrobenzene as an attractant was again tested on sod webworms and found effective.

The development of mule-drawn dusting machinery has been continued. The tandem-wheel, two-row duster mentioned in the last annual report is being made commercially. It supplies the need of the larger acreage very well, but on account of its cost a lighter and cheaper two-row machine has been devised for smaller acreages and will be tested during the present season.

An excellent piece of work has been accomplished at the Quincy, Fla., laboratory in fully working out the life-history stages and seasonal history of the tobacco flea-beetle and in completing a long existent gap in seasonal history of the tobacco budworm. Preliminary control work was instituted against the budworm in the sun-tobacco district at Tifton, Ga., and a method of control adapted to sun-tobacco conditions was partially worked out.

SUGAR CANE, RICE, AND CACTUS INSECTS.—Work has been continued on the rearing and release of *Habrobracon brevicornis*, a parasite of the European corn borer which was found to attack the sugar-cane moth borer. The parasite has not yet been recovered in the field.

The tachinid parasite *Lixophaga* (*Euzenilliopsis*) *diatraeae*, introduced from Cuba in 1919 and 1920, was found in the fall of 1922 to be present on 14 plantations out of 41 where releases had been made. Since the parasites were released they have been found at 25 plantations altogether, but hardly a trace of them can be found in a field after one or two hours' careful search. It seems that the parasites are merely able to survive without multiplying to any extent or that they are attacking the moth borer over a wide radius from the place of release. Hundreds of borers are collected every summer for other experiments, but a parasite is never found among them. It is worthy of note that one parasite of this species was found at Pass Christian, Miss., though none was released nearer that place than New Orleans, nearly 60 miles away.

Experiments were conducted in soaking sugar-cane stalks in hot water to kill borers before planting. Dr. E. W. Brandes, of the Bureau of Plant Industry, suggested such work as a method of securing uninfested seed cane for an experiment station of the Bureau of Plant Industry, and it was also his idea that the growth of the cane would be hastened. An immersion for 20 minutes in water at 50° C. was found to kill all borers and also to hasten the germination. The treatment was satisfactory on cane planted in the fall, but many eyes were killed on cane planted in the spring.

Chemicals applied to planted cane to destroy borers in the stalks have not so far been found satisfactory.

Life-history studies are being conducted in cooperation with the Mississippi State Plant Board on the new pink borer of sugar cane found near Gulfport. More recently one specimen of this insect, the adult of which is unknown, was found in corn near New Orleans, but in the direction toward Gulfport. While the insect is capable of considerable injury, its life cycle seems to be so prolonged that it seems unlikely to become of any great importance. There is probably only one generation during the year.

Work was done during the fall and winter at Cairo, Ga., in mapping out the distribution of the sugar-cane mealybug, which was not previously reported from that section. It was at first thought that eradication might be possible, but the mealybug was found generally distributed over the sirup-producing section around Cairo. Experiments in controlling the ants in the fields, and thus controlling the mealybugs which they protect, were started.

The various pests of the rice plant and their control are being studied.

A trip was made during the winter to the west coast of Mexico and Lower California in company with two employees of the Federal Horticultural Board. Information was secured on the distribution of sugar-cane insects, and a borer, *Diatraea canella*, was found which had not previously been reported from Mexico. A tachinid parasite, *Phorostoma* sp., was found in tunnels of sugar-cane borers at Tepic.

INSECTS AFFECTING THE HEALTH OF MAN AND DOMESTIC ANIMALS.

THE SCREWORM AND BLOWFLIES.—Investigations under this project have been continued at the field stations of the bureau located at Dallas, Uvalde, and Sonora, Tex. Certain phases of this work have been carried on in cooperation with the Bureau of Chemistry and the Texas Agricultural Experiment Station as heretofore.

Tests of the efficacy of several different types of traps, bait pans, and baits under range conditions have been continued. The conical screen trap advocated by the bureau is now being rather generally used in the worst screwworm districts of the Southwest with very satisfactory results. Experiments carried out during the fiscal year indicate that where wild animals, such as rabbits and prairie dogs, may be obtained readily for bait they may be more economically used than commercial dried baits, especially if they are kept moist and maggot breeding is prevented by surrounding the bait in the pan with water containing borax or nicotine sulphate. By the use of these larvicides, the attractiveness of the bait is prolonged, since it is not so promptly destroyed by the maggots. Further experiments with commercial dried egg have been carried out. It has been found that this forms a very satisfactory and reasonably priced bait when each bait pan is charged with 6 ounces of dried egg to which have been added 5 grams of sodium carbonate and $1\frac{1}{2}$ quarts of water.

Experiments with larvicides for use in destroying screwworms and other maggots in wounds on livestock have been continued. As a result of this work it has been found that benzol (100 per cent) is very promising. It is not only reasonable in price, but destroys the larvæ well, does not have a deleterious effect on the wound, and has good keeping qualities.

Extensive tests have been carried on with various chemicals with a view to securing suitable repellents for use in keeping flies from infesting wounds. Experiments with meat placed in jars under close observation have been continued on an extensive scale, and many of the most promising repellents have been tested on livestock under range conditions. Among the most promising mixtures thus far discovered are furfural 1 part, commercial pine-tar oil 3 parts, and safrol 1 part, medium pine tar, 3 parts. Several of the lighter pine-tar oils have shown marked repellent effect. It is planned to test on wounds the whole pine-tar series in combination with other repellents.

THE OX WARBLE OR GRUB OF CATTLE.—This project has been continued along the lines indicated in previous reports. Further information of considerable economic value has been obtained on the biology and seasonal history of the two species of warbles in different parts of the country. A few preliminary experiments have been inaugurated to determine the damage caused by this insect, especially on dairy cattle.

Some educational work incidental to the investigations has been done with a view to showing the livestock raisers the importance of the control or eradication of this pest. As a result of this year's work no information has been gained which indicates that eradication on a county basis as planned will not prove successful if properly financed.

A number of tests have been made with the destruction of the warbles in the backs of cattle by applying powders and washes. As a result of this work it has been found that over 98 per cent of the grubs can be killed with a general application to the backs of cattle of powdered derris root. A wash consisting of 1 pound of derris, 4 ounces of soap, and 1 gallon of water has also given a percentage of kill above 96. An ointment consisting of 1 part derris and 5 parts vaseline has also given almost 100 per cent kill when the material was pressed into each hole. Injections of 100 per cent benzol with an oil can have also given almost complete destruction of all warbles treated.

LICE AFFECTING LIVESTOCK.—Investigations of the life history, habits, and longevity of the biting and sucking lice of the goat have been carried forward in cooperation with the Texas Agricultural Experiment Substation No. 14 at Sonora, Tex. Much difficulty has been experienced in attempting to rear these insects under control, thus making progress slow. Some experiments with the dipping of goats in arsenical solutions of different strength have also been carried out.

Further tests of insecticides in dry form have been made against cattle lice. In this work the discovery that hellebore when dusted over lousy animals will give complete destruction of both biting and sucking lice is worthy of note.

POULTRY PARASITES.—Further studies on the biology and control of the stick-tight flea have been carried out at the Uvalde station, and a brief report of the work has been published in the Journal of Agricultural Research. Additional experiments on the control of the common poultry mite and the fowl tick or "blue bug" have been carried out. In this connection some attention has been given to the possibility of destroying these and other external parasites of poultry by administering certain chemicals and chemical compounds in the food and water.

MALARIA MOSQUITOES.—The clinical and biological investigations of certain experimental control measures, conducted by the International Health Board and the bureau, were brought to a close at the end of 1922 upon the completion of the original three-year program. The accumulated notes and records were then taken to Baltimore, where, with the assistance of the department of biometry and vital statistics of the Johns Hopkins School of Hygiene and Public Health, the data were summarized and studied and reports prepared for office records and publication.

The full report covering this work was divided into the following sections, the titles of which indicate the field covered by the joint investigation:

- The experimental control units and comparative malaria incidence.
- A statistical study of the occurrence of malaria in the population as a whole.
- Collections and comparative abundance of *Anopheles* in different units and localities.
- Studies of *Anopheles* infection under natural conditions.
- The identification of the blood meal of mosquitoes.
- The blood-feeding habits of malaria-carrying mosquitoes.
- Preferential feeding experiments with *Anopheles*.

Of the above, the last three manuscripts dealing with the blood-feeding habits and host preference of *Anopheles* were prepared for

immediate publication and were submitted to the American Journal of Hygiene.

The larval investigations which have been carried on by the bureau during the past three years, independently of the cooperative work, have also been summarized and a complete report prepared. From this, one article has been prepared in condensed form for publication, giving an account of the natural breeding places of *Anopheles* in the locality of Mound, La.

At the beginning of the present season, work was started on the following three projects and is now being conducted along these lines:

Methods of larval control adapted to local conditions.

Chemotropic responses and trapping of adult *Anopheles*.

Continuation of the host-preference experiments. (In cooperation with the department of immunology of the Johns Hopkins School of Hygiene and Public Health.)

INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES.

Dr. A. D. Hopkins has continued as leader of this branch of the bureau work.

INSECTS DAMAGING FOREST TREES.

Studies of the principal forest insects of the United States, and especially of the destructive pine bark-beetles, carried on for many years, have resulted in the gaining of knowledge which is now being put into effect in the most practical way in large-scale forest-insect control carried on in cooperation with private owners and other branches of the Government service. Some of the principal projects are mentioned below.

THE SOUTHERN OREGON-NORTHERN CALIFORNIA CONTROL PROJECT.—In my last annual report I stated that this control project is the largest single one of the kind ever attempted. It is now in its second season, and it is expected that the bulk of the work will be completed by the close of the season of 1924. The cooperation has been admirable. The Forest Service of this department, the Indian Service of the Interior Department, and the private owners, represented by the Klamath Forest Protective Association, have worked in the greatest harmony, and the operations have been planned and supervised by the Bureau of Entomology. The area over which this epidemic of pine bark-beetles extends is a little larger than the State of Delaware, and in the last 10 years in this region the western pine beetle has killed over a billion board feet of merchantable yellow pine timber valued at over \$3,600,000. It may incidentally be mentioned that this is fifty times as much as has been killed by fire on the same area during the same period. It has already been shown that with the establishment of as effective beetle control as has been established for forest-fire control, losses due to the beetle can be reduced to a minimum. Since the project was started last year, 260,343 acres have been gone over at a total expense of about 36 cents per acre. It will take another year to finish this work, and then, with some expenditure for maintenance, it is very probable that nearly complete control of the possible insect damage can be maintained. The private owners, the officials of the Forest Service, and those of the Indian Service are greatly pleased

by the results of this work and enthusiastically advocate its continuance.

THE ANTELOPE CONTROL PROJECT.—This project is located in northern California, and has been carried on in cooperation with a lumber company. The cost of this work has been paid by the owners, and it was done under the supervision of an expert of the bureau located at the Ashland (Oreg.) station. The work has been practically completed except for subsequent maintenance work. An area of 52,000 acres was brought under control, and the annual loss on the area has been reduced to from 1.4 to 0.4 per cent. The annual saving indicated shows a considerable profit over the cost of the operations.

GRAND CANYON-KAIBAB CONTROL PROJECT, ARIZONA.—This project, mentioned in my last report as having been entered upon cooperatively by the Forest Service, the Park Service, and this bureau, was undertaken on account of the beetle infestation over an area including about 80,000 acres in the Grand Canyon National Park and the Kaibab National Forest. More than 20,000 acres have been covered in the work so far.

OTHER CONTROL PROJECTS.—A test of maintenance control is now in its fourth season, in cooperation with the Forest Service, under the title "The San Joaquin project." A small investigational project along maintenance lines has been begun in the Helena National Forest, in Montana, and another one of the same character has been carried on in the Santa Barbara National Forest under the title of "The Figueroa project." Examinations which have been made over an area on the Modoc National Forest, in California, indicated infestation by bark-beetles, and control work has been begun by the Forest Service under the supervision of experts of this bureau. Other field studies have been made over areas of wind-blown timber and of slash, and certain conclusions of practical value have been reached.

THE SOUTHERN PINE BEETLE.—During the latter part of 1922 and early in 1923 it became obvious that a serious outbreak of the southern pine beetle was threatening in southern Virginia. In this region this insect had not occurred in dangerous numbers for many years. Demonstration control work in Accomac and Northampton Counties, Va., and at Ashland, Va. (near Richmond), have resulted in effective control, and a threatening epidemic has apparently been checked. There is some evidence that this southern pine beetle is locally destructive in other more southern States, and examinations are to be made in these regions in the near future.

THE SPRUCE BUDWORM.—The spruce budworm has been studied in New England and in the Lake States, and has made its appearance in injurious numbers in northern Idaho. What appears to be this species is also causing the defoliation of the Douglas fir and the Engelmann spruce in the Yellowstone National Park in Wyoming. It is being studied by one of the department's experts stationed at Coeur D'Alene, Idaho.

OTHER FOREST INSECTS.—Additional studies have been made of the Pandora moth, which has been defoliating pines near the Klamath Indian Reservation in Oregon, of the ~~large~~ sawfly which threatens an outbreak in the upper peninsula of Michigan, of the Nantucket pine moth, which is doing some destructive work at Halsey, Nebr.,

and of pine needle miners, which are apparently increasing in parts of Oregon.

INSECTS AFFECTING FOREST PRODUCTS.

Studies have been made and practical experiments carried on in connection with insect damage to crude forest products as well as finished forest products. Variations in management and experiments in sun curing, water submerging, seasonal cutting, and chemical sprays have been carried on with very satisfactory results in nearly all cases. Studies of chemical ~~root~~ preservatives, of woods resistant to the attack of white ants, and of the effect of different temperatures in kiln drying for killing the powder-post beetles have also given interesting results. Much technical research work with the insects concerned has been done.

INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS.

The demand for information concerning insects of this class is rapidly increasing. Many hundreds of letters of inquiry are received from all parts of the country. Special studies are being made of a number of species of insects that attack trees of this class, special work being done in the East (at Washington) and in the far West (at Palo Alto, Calif.), and the bureau is now in a position to give advice in this direction which will be of great use to the parking authorities of cities and towns.

BEE-CULTURE INVESTIGATIONS.

The work of the bee-culture laboratory, under the supervision of Dr. E. F. Phillips, has been continued along the same general lines as formerly. The laboratory and the apiary of the bureau are located at Somerset, Md., near Washington.

BEHAVIOR OF BEES.—The work on the responses of bees to changes in the temperature and humidity conditions of the bee colony was continued through the entire active season of 1922 and the same work was carried on during the month of May, 1923, in order to increase the data for the period of the heaviest honey flow. It is found that there is a definite and very close control of the temperature of that part of the hive in which brood is reared, but that in the parts of the hive in which nectar is being stored and ripened into honey the bees exercise little if any temperature control. This at once suggests the desirability of insulation for the part of the hive devoted to honey storage, but further experiments will be necessary to determine whether this would add materially to the honey crop. Extensive records have now been collected and work has been begun in their analysis and in preparation of some of the data for publication. It is found that each honey flow exhibits characteristic changes in the weights hour by hour, doubtless because of variations in the time of day when nectar secretion occurs in the different species of plants.

The investigation of the amount of brood within certain colonies at weekly intervals throughout the brood-rearing season, conducted by W. J. Nolan, is being continued with a few colonies during the present season. During the summer of 1920 records were made on

five colonies by direct counting of the brood. In order to interfere less with the colony activity, records were made during 1921 by means of photographs of the sealed brood in 16 colonies, and in 1922 this was done with 32 colonies. The work during 1923 is on 8 colonies only, to clear up certain points not fully explained by the previous data. A manuscript has been submitted for publication giving a summary of the results of the work for the first two years, and two papers have been prepared for publication outside the department in which certain points in this investigation are discussed.

During the latter part of the season of 1922, observations were made on the feeding and care of honeybee larvæ during the various periods of their larval development. It is found that the food given the larva just after hatching is given at one time, in what has been designated mass feeding. After the original food supply is exhausted, which occurs at about the end of the second day of larval life, feeding continues as needed by the larva by what has been designated progressive feeding. The change from mass feeding to progressive feeding is doubtless correlated with the change in the composition of the larval food which has long been known to occur, but which was formerly believed to occur much later. A manuscript on this subject has been submitted for publication by the department. The work on the responses of bees to light of various colors and intensities was continued through the active season of 1922 and has been renewed during the present season.

The manipulation of wax and wax scales by the bees has also been studied, carrying this work on from the points studied by Casteel several years ago in this laboratory, and the manner in which the wax is handled by the mandibles of the bee when being elaborated into the comb has been determined.

The work on the flight of bees by the special apparatus devised by A. E. Lundie has been completed and the results incorporated in a manuscript which has been submitted for publication by the department. A large variation has been found in the flight of bees according to temperature conditions and also with regard to the honey flows.

PHYSIOLOGY OF BEES.—The work mentioned in the last report on the availability of various carbohydrates to bees has been continued, certain additional observations having been advisable because of the publication of a paper by certain foreign observers on the enzymes found in the alimentary tract of the bee, the results of which failed to agree fully with the findings in the present investigation. A repetition of the work with certain modifications has failed to change in any way the results reported last year, from which it is concluded that the determination of the enzymes in the alimentary tract alone is not a reliable guide in determining what foods are available to honeybees. A brief summary of the results of this work has been prepared for publication outside the department.

The work on the changes in the oenocytes according to the age of the worker bee has been continued during the present active season. While certain changes are observed in these peculiar cells during the course of the life of the worker bee, the significance of these changes is not yet wholly clear.

The rate of growth of the honeybee larvæ has long been recognized as exceedingly rapid. During the past year a paper by Drs. James

A. Nelson and A. P. Sturtevant was submitted for publication, in which the results of careful weighings were recorded at intervals during the entire period of larval development and during the first part of the period when the developing larva is sealed over. It is found that the larva increases in weight 1,550 times during a period of five and a half days and that during the early part of the larval period the rate of development may reach 621 per cent a day.

It appears that the number of molts of the developing larva has never been accurately determined. A study of this subject has been undertaken and it has been found that, in spite of the excessive rate of development and the constant increase in size during the feeding period, there are but four molts during larval life, and that considerable increase in body size and weight occurs between molts.

In connection with observations on the behavior and physiology of the bee, constant need is felt for more detailed information on the anatomy of the adult bee.

The study of the colors of American honeys, begun in cooperation with the Bureau of Agricultural Economics, has been continued during the present active season. The various samples of honey, 450 in all from all parts of the country, have all been measured for the transmission of lights of various wave lengths by means of the spectrophotometer, and the samples have been arranged according to this transmission of light. There are no natural divisions of honey into colors, so that whatever grades are established must be more or less arbitrary. An effort is now being made to obtain materials which will give proper color values for honey graders.

The examination of the pollen grains in the honey samples collected, which is being done in the microchemical laboratory of the Bureau of Chemistry, has shown that in all probability this is not a safe way to determine the floral source of honeys, as has been commonly assumed.

In connection with the study of the colors of honey, it was found that honeys vary greatly in their transparency even though there is no granulation. To determine the cause of the cloudiness, arrangements were made during the past fiscal year for a cooperative investigation of the materials in honeys other than the three common sugars, and an expert was appointed for this work, which is being done in the carbohydrate laboratory of the Bureau of Chemistry. Five separate plant-coloring materials have so far been extracted from normal honeys. Some of the coloring materials are colloidal, which doubtless accounts in part for the cloudy effects observed in some samples.

DISEASES OF BEES.—Work on the distribution of the Isle of Wight disease of bees has been continued through a careful survey of all records available from foreign countries, and a manuscript has been submitted for publication in which are recorded for the use of American beekeepers all available data on this subject, together with a statement regarding the steps taken by other countries to control this disease or to prevent its introduction where it is not yet found. The disease is now definitely found throughout the British Isles, in France, and in French Switzerland. Importation of bees has been restricted in Switzerland, the Union of South Africa, Australia, and the Dominion of Canada, as well as in certain other countries,

in order to prevent the further spread of this serious disease of adult bees.

Work has been continued on the examination of diseased or abnormal adult bees from all parts of the United States. During the active season of 1922 samples to the number of 184 were examined, but just as in this work for 1921, no samples were obtained in which the mite causing the Isle of Wight disease was found. During the season of 1923 this work is being continued, and so far the results are still negative for bees from the United States. The records of the examinations for 1922 are incorporated in the above-mentioned manuscript on the distribution of the Isle of Wight disease.

On the basis of the negative findings in the search for the Isle of Wight disease in the United States, as stated in the last report, a bill was introduced into Congress to prohibit the importation of adult bees, except from countries in which it is determined that no diseases dangerous to adult bees exist or for experimental or scientific purposes by this department. This bill was passed by Congress in August, 1922, and was approved by the President on August 31, 1922.

In accordance with the provisions of this act, regulations have been approved by the Secretary of the Treasury and the Secretary of Agriculture which permit the importation of adult bees without restriction from the Dominion of Canada and which further define the methods by which adult honeybees may be imported for experimental and scientific purposes. Additional special rules on this subject were more recently approved by the Secretary of Agriculture. Provision is made for importations necessary to prevent any deterioration of the stock of the bees in this country and for providing all scientific workers with necessary imported breeding stock. Since the regulations and special rules were not adopted until near the close of the fiscal year, no importations could be made until after the close of the year, but arrangements were made for the importation of some breeding stock under the provisions of the regulations.

A manuscript has been prepared dealing with the morphological structures involved in the Isle of Wight disease, with a discussion of the respiratory system of the normal bee. This clears up many questions regarding this disease, which is concerned solely with the respiratory system.

The investigations on the etiology of the brood diseases of bees have been continued. A paper has been submitted for publication in which the results of the biochemical study of the larva before and at the time of death by American foulbrood are discussed. It is found that the development of the causative organism and the consequent death of the larva do not occur until the sugar content of the larval intestine is quite low, and that this is the cause of the marked regularity in the time of death and in the resulting uniform positions of the dead larvæ which are characteristic of this disease, and in marked contrast to conditions found in the other disease of the brood of bees, European foulbrood. The results of this investigation of the chemistry of the larvæ were correlated with the biochemical and cultural characteristics of the causative organism. In order that this investigation might be carried out, it was necessary to devise somewhat new methods of analysis, and thus for the first time it was established that there is a considerable unassimilated sugar content in the developing larva. This work was cor-

related with the glycogen, fat, and nitrogen content of the larvæ and pupæ, both in health and in disease.

During the past fiscal year samples were again examined for beekeepers and apiary inspectors, and this is one of the most valuable routine services rendered by the laboratory. During the year 1,029 samples of brood and adult bees were examined.

BEEKEEPING REGIONS OF THE UNITED STATES.—Lack of funds has prevented much work on this subject during the past year, although there is great need for additional investigations. A considerable amount of information on this subject constantly comes to the laboratory from all sources and this is carefully catalogued for future use, when more serious investigations become possible.

DEMONSTRATIONS IN BEEKEEPING.—The work on this project has been still further decreased during the past year. During and immediately following the war there was such a demand for this work that the time and funds of this office were largely directed toward the education of practical beekeepers. Gradually this work has been turned over to the several States and at present the bureau is co-operating in this work in only three States. Arrangements are being made still further to curtail this support in the near future. No marked change in the policies of this work has taken place during the past year, emphasis still being given to the proper training of those who desire to make beekeeping a major part of their work.

The extension work begun by this office in various States has been continued by the several States almost without exception, indicating that it fills a real need in the promotion and development of beekeeping in this country. With the present condition of the honey market and the low prices obtained by beekeepers for their products, beekeeping is in great need of proper encouragement in order to continue the industry in the place which it attained during and immediately after the war. No extension short courses for commercial beekeepers were held during the past year.

MISCELLANEOUS ACTIVITIES.—The correspondence of the office continues to be heavy. While the beekeepers of the country are considerably discouraged at present because of low honey prices in the general market, they are as a rule still caring for their bees as well as formerly and are continuing to send inquiries to this office as much as formerly. Part of the heavy correspondence of the office arises from the examination of samples of bees and diseased brood of bees and from the examination of honeys for color.

Mention should be made of the cordial cooperation received by this office from other divisions of the department the work of which concerns the beekeeper. The carbohydrate and microchemical laboratories of the Bureau of Chemistry are both rendering valuable aid. Three offices of the Bureau of Agricultural Economics are doing work of great benefit to beekeepers and the cooperation with the extension offices of the department continues to be cordial in the management of the decreasing amount of extension work which this office is doing. From time to time various other offices and bureaus must be called upon in the work of this division, and in all cases the response is all that may be asked. Because of the widely diversified nature of the work of this division, such cooperative efforts are made vitally necessary, and it is extremely fortunate that the beekeepers of the country may have the facilities of all these divisions of the department at their disposal.

INSECT PEST SURVEY.

J. A. Hyslop has continued in charge of this branch of the bureau's work since its inception in March, 1921. The survey has now functioned two years and three months. It has filled the need that has long been felt among entomological workers for a medium through which they could be kept closely in touch with insect conditions in the various parts of the country, and for a permanent record of these conditions correlated with the prevailing meteorological conditions from year to year, which should, in time, serve as a fundamental basis for the next departure in economic entomology; i. e., entomological forecasting. This work has been so successful that a similar survey has been inaugurated within the year in the Dominion of Canada, along lines very similar to those of the bureau's organization.

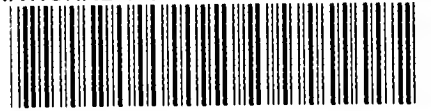
During the fiscal year 1923 the survey completed volume 2 of its monthly bulletin, comprising Nos. 5 to 8, inclusive, 130 pages of text material and an index of 34 pages, and the first 4 numbers of volume 3, comprising 162 pages of text material. The magnitude of this work is indicated in that 507 different species of insects were recorded in volume 2 of the Insect Pest Survey Bulletin as of more or less economic importance in some part of the United States.

As an incident to the work of the survey a card index has been prepared of the common names applied to insects in this country. This card index now includes about 4,500 common names. The index is arranged alphabetically, first, under the common names and, second, under the Latin names, which facilitates the finding of the common name of any insect. This card index is now also being used by the bureau committee which is cooperating with the American Association of Economic Entomologists in standardizing common names, and forms a basis for the work of this committee.

During the past year the entomologist in charge of the survey held one meeting of the survey's collaborators at the time of the annual meeting of the American Association of Economic Entomologists. At this meeting considerable progress was made in organizing the survey and standardizing survey methods. In addition, a cooperative agreement was effected with the entomologist of the Dominion of Canada for an exchange of notes, whereby each survey now publishes the outstanding entomological features of the neighboring country.

During the past season the annual summary for 1921 was issued, comprising a report on 19 of the more important insects of the year. It has been found very desirable to increase materially the scope of the annual summary, and the summary for 1922 will cover 39 species of insect pests. Owing to this increase in the scope of the work and the increasing mass of material being received by the survey from its collaborators for monthly publication, the completion of this summary is very much delayed.

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